Meet The Oceanographers

WIND JETS, FISHING, AND WINDSURFING

Dudley Chelton windsurfing.

I'm Dudley Chelton and I am a professor of oceanography at Oregon State University in Corvallis, Oregon. One of the things that I have been studying is the sudden outburst of gale-force and sometimes hurricane-force winds that occur about a dozen times a year during the fall, winter and spring at three places along the Pacific side of Central America [Fig. 1]. I have been working with satellite radar data for the past 18 years and I am now using it to study these wind "jets."

A radar sends a pulse of microwave radiation toward the sea surface and measures what comes back. This is the same kind of radiation that is used to heat food in your microwave oven at home. One of the great advantages of microwave radiation is that it can "see" the sea surface through all kinds of weather conditions, including very heavy clouds. One way that satellite radars are used is to measure the time required for a radar pulse to travel from the satellite to the sea surface and then back to the satellite. By this technique, a *radar altimeter* measures the sea surface height. The radar data can also be analyzed in a different way by measuring the power that is scattered back from the sea surface. This power can be directly related to the roughness of the sea surface caused by blowing winds. In this way, a satellite radar such as the NASA Scatterometer (NSCAT) can very accurately infer the wind speed and direction at the sea surface. Satellite scatterometers provide maps of the winds over the entire world every few days.

The winds I am studying have a very interesting effect. When they blow off the land, they stir up the ocean, mix and upwell cold, deep water to the sea surface. Mixing and upwelling are very important processes because deep water contains the nutrients that allow plankton to grow. Since plankton are the food source that is necessary for fish to survive, the best fishing is usually found near cold, upwelled water. The three windy places off Central America are famous for their major fishing industries.

Until recently, the cause of the three wind jets off Central America and the fate of the winds after they leave the coast have been puzzles

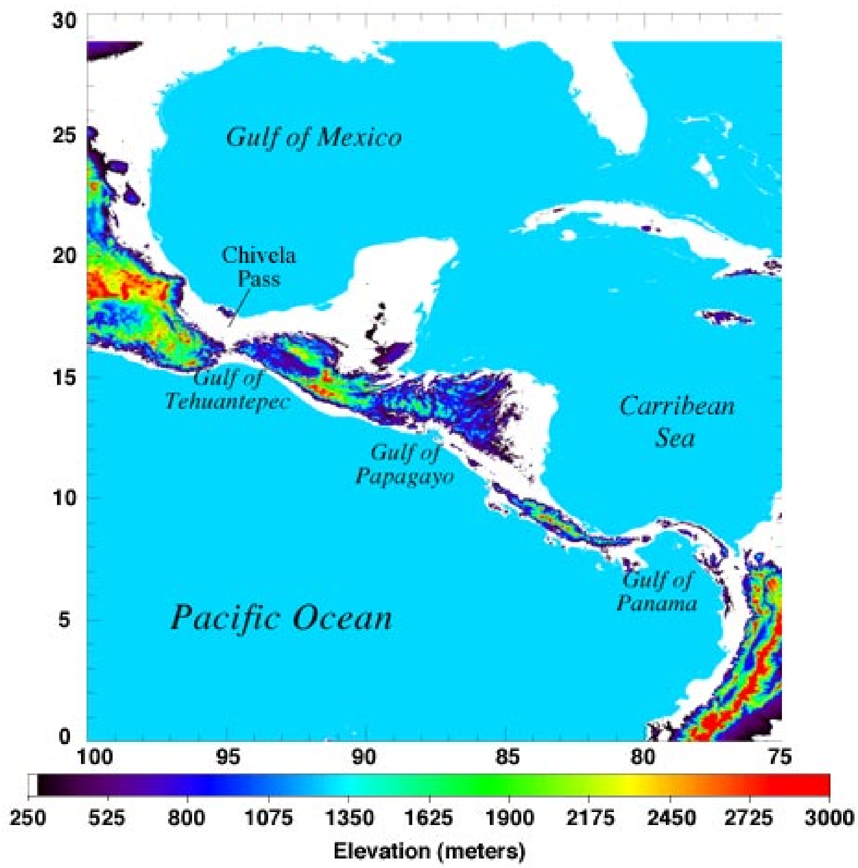

Figure 1. Map showing the geography of the region of strong wind jets in the eastern tropical Pacific. The white and colored areas in Central America correspond to topographic elevations according to the scale shown at the bottom of the figure.

because there are so few ship-based wind observations in this region. By analyzing the NSCAT data, we have been able to piece together the following story.

There is a mountain range called the Sierra Madre that runs down the middle of Central America through Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama with peaks that are up to 10,000 feet high. There are three gaps through this mountain range where the elevation dips to heights of less than 750 feet. During wintertime, cold air masses over Rocky Mountains in the United

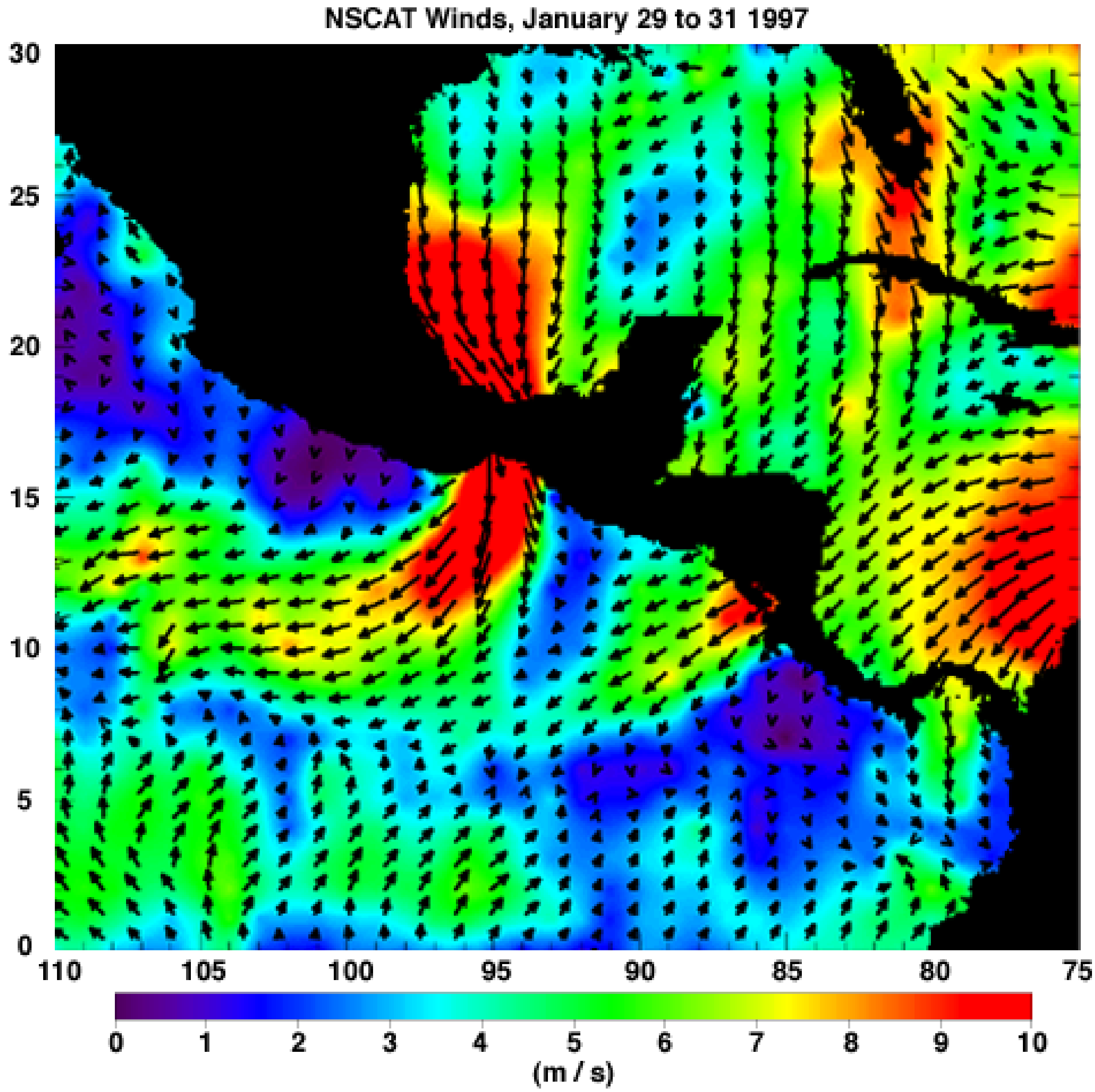

Figure 2. Average winds measured by the NSCAT over the 3-day period 29-31 January 1997. The color coding corresponds to the wind speed. During this event, the winds were blowing very strong over the Gulf of Tehuantepec, extending about 700 km into the Pacific. Moderately strong winds were blowing over limited regions of the Gulfs of Papagayo and Panama.

States sometimes move south over Gulf of Mexico. It was previously thought that this pushes air through all three mountain gaps. The NSCAT data show that the cold air outbreaks only affect the northernmost gap, called Chivela Pass. The winds blow at speeds of 50 mph or more down the hillsides from Chivela Pass and over the waters of the Gulf of Tehuantepec, sometimes extending more than 500 miles into the Pacific Ocean [Fig. 2].

The surface waters under the Gulf of Tehuantepec wind jet can cool by as much as 15ºF in a few hours, which is a huge temperature change in the ocean! In addition to the cold water that is detectable from other satellite sensors [Fig. 3], the ocean's response to these winds shows up in satellite estimates of chlorophyll from ocean color measurements [Fig. 4] (see also *The Color of El Niño*). The cold water and high chlorophyll concentration are signatures of mixing and upwelling of cold, nutrient-rich deep water. Fish converge on this food source, which supports the highly successful fishing industry in the Gulf of Tehuantepec.

The Tehuantepec winds also play another important role in the economy of the region. The city of Salina Cruz on the coast directly south of Chivela Pass gets an average of 140 days of gale-force or stronger winds each year. As a consequence, Salina Cruz has become a major destination spot for the popular sport of windsurfing, which is one of my favorite activities outside of work. Someday I hope to go to Salina Cruz and study these winds and the rough sea surface up close from my windsurfer.

We are presently analyzing NSCAT data to determine what makes the winds blow through the other

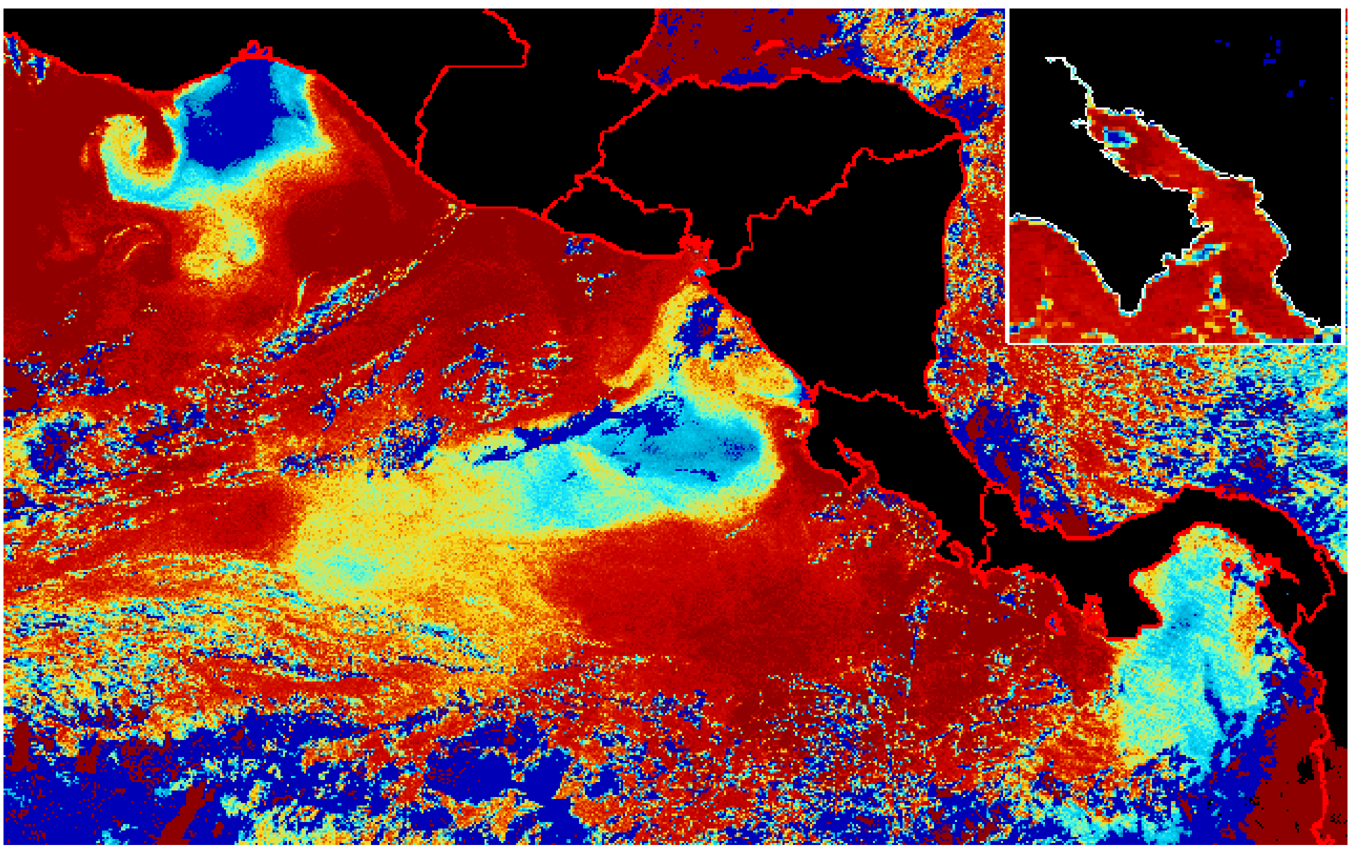

Figure 3. Sea surface temperature measured by the Advanced Very High Resolution Radiometer (AVHRR) on 30 January 1997 (the same time as the 3-day composite average NSCAT wind map shown in Figure 2). The blue regions correspond to cold water from wind-induced mixing and upwelling in the Gulfs of Tehuantepec, Papagayo and Panama. Figure courtesy of Carlos Carlos Brenes, Laboratory of Physical Oceanography, National University , Heredia , Costa Rica.

two gaps in the Central American mountain range and over the Gulf of Papagayo and the Gulf of Panama. From the analysis that we have done so far, it appears that these winds are driven by the tradewinds over the Caribbean Sea, rather than cold air outbreaks from North America.

Unfortunately, NSCAT stopped working on June 30, 1997 because the satellite lost its solar panel that provides power to operate the scatterometer. During this Year of the Ocean, 1998, I will be working with a team of scientists and engineers on a new satellite scatterometer called QuickSCAT, which will provide a Quick replacement SCATterometer for NSCAT. NASA and JPL are working hard to have QuickSCAT ready for launch in November 1998.

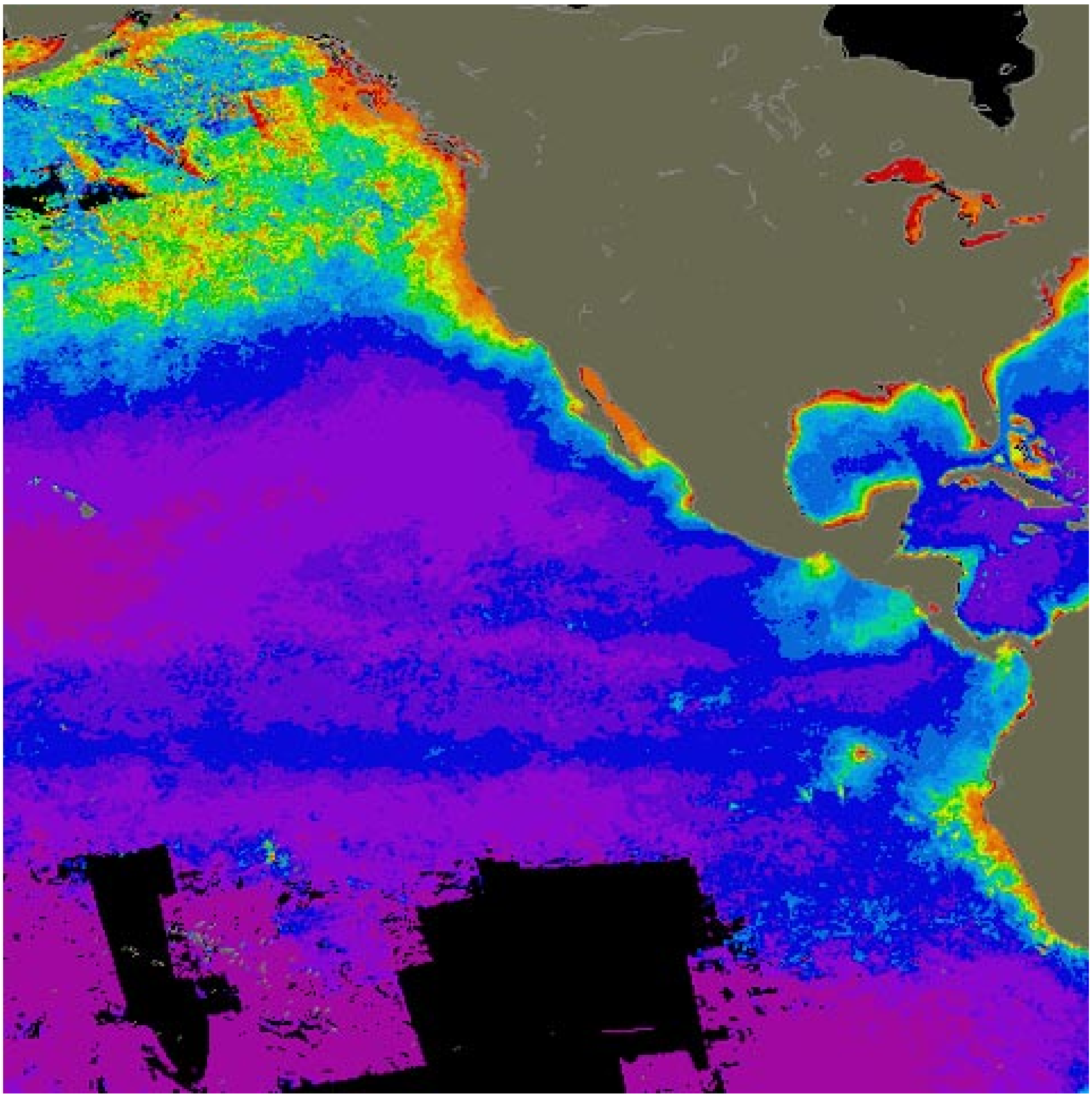

Figure 5. Average ocean color during the winter season. Red and yellow areas correspond to high chlorophyll concentrations and blue and green areas correspond to low chlorophyll. Note the localized region of very high chlorophyll concentration in the Gulf of Tehuantepec, Papagayo and Panama.